NIA Project Registration and PEA Document

Date of Submission:

*Notes on Completion: Please refer to the NIA Governance Document to assist in the completion of this form. Please use the default font (Calibri font size 10) in your submission. Please ensure all content is contained within the boundaries of the text areas. The full-completed submission should not exceed 10/12 pages in total.*

1. Project Registration

|  |  |  |
| --- | --- | --- |
| Project Title (*This cannot be changed once registered*) |  | Project Reference |
| Practical Transition into wider EMT GB Modelling |  | NIA2\_NGESO035 |
| Funding Licensee(s) |  | Project Start Date |
| NGESO |  | July 2023 |
| Nominated Project Contact(s) |  | Project Duration |
| Jay RamachandranGopi Yericherla  |  | 21 Months |
| Contact Email Address |  | Project Budget |
| innovation@nationalgrideso.com |  | £350,000 |

**Project Summary (125 words limit)**

With increasing number of IBR sources in the GB system, Electromagnetic Transient (EMT) simulations must be carried out for many scenarios and several contingency cases to analyse system stability. There is a growing need to develop a capability to carry out multiple EMT analyses for wider network studies with reduced and practical simulation time.

This project will develop innovative methods to accelerate the simulation time to run the full GB EMT model and provide technical guidance to determine when EMT simulations are necessary under critical system conditions.

The project has two main objectives:

* Improve the efficiency of EMT simulations, with the overall objective of running the National Grid Electricity network model in PSCAD to achieve practical run time.
* Produce the technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.

**Benefits Summary (125 words limit)**

The project will enhance the GB network's EMT model by improving the models' computational efficiency, which will help investigate more scenarios with stability risks while transitioning into zero carbon operation. It will also provide technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.

The learnings from this project will also be beneficial to Transmission Owners (TOs) concerning the run time of their respective EMT networks. The TOs use the same EMT software package, and the developed tool should be able to integrate with their models seamlessly. Furthermore, the second phase of the innovation project will produce technical guideline outlining the scenarios for which EMT simulations are necessary under system-critical conditions for better-informed decisions.

**Lead Sector**

|  |  |
| --- | --- |
| Electricity Distribution | Gas Distribution |
| Electricity Transmission | Gas Transmission |

**Other Sectors**

|  |  |
| --- | --- |
| Electricity Distribution | Gas Distribution |
| Electricity Transmission | Gas Transmission |

**Primary Research Area** *(Please select just one)*

|  |  |
| --- | --- |
| Net zero and the energy system transition | Optimised assets and practices |
| Flexibility and Commercial Evolution | Whole Energy System |
| Consumer Vulnerability | Data and Digitalisation  |

**Secondary Research Area** *(Please select up to two)*

|  |  |
| --- | --- |
| Net zero and the energy system transition | Optimised assets and practices |
| Flexibility and Commercial Evolution | Whole Energy System |
| Consumer Vulnerability | Data and Digitalisation  |

**Development steps**

|  |  |
| --- | --- |
| Technology Readiness Level (TRL) at Start  | TRL at Completion6 |

1. Project Details
	1. Problem(s)

This should outline the Problem(s) which is/are being addressed by the Project. This cannot be changed once registered.

Root Mean Square (RMS) simulation is traditionally adopted for a simplified approach by representing the system in the phasor domain for large-scale power system stability studies. RMS simulations have proven reliable results when power systems are predominantly based on synchronous machine-based generation. However, with the rapid penetration of power electronic (PE) devices in the system, the system's dynamic performance is likely to experience significant changes due to the characteristics of PE-based devices that may not be accurately captured by RMS studies alone. The classical RMS model might not accurately capture the dynamic behaviour of the network.

Therefore, Electromagnetic Transient (EMT) analysis is required to analyse system operational risks, such as control interaction and sub-synchronous resonance issues with the high penetration of Inverter Based Resources (IBR). NGESO is working with TOs in the TOTEM innovation project (NIA\_SHET\_0035) to develop an EMT model representing the whole GB system.

The EMT simulations usually take a considerably longer time when compared with RMS simulations, even for simple networks. Currently, the developed full GB EMT model takes several hours to run 20 seconds of simulation in PSCAD. Also, with the increasing number of IBR sources in the GB system, EMT simulations must be carried out for many scenarios and several contingency cases to analyse system stability. There is an increasing need to develop a capability to carry out multiple EMT analyses for wider network studies with reduced and practical simulation time.

* 1. Method(s)

This section should set out the Method or Methods that will be used in order to provide a Solution to the Problem. The type of Method should be identified where possible, eg technical or commercial.

For RIIO-2 projects, apart from projects involving specific novel commercial arrangement(s), this section should also include a Measurement Quality Statement and Data Quality Statement.

This project seeks to achieve two main objectives –

* Improve the efficiency of EMT simulations, with the overall objective of running the National Grid (England & Wales) Electricity network model in PSCAD to achieve practical run time.
	+ Deliver enhanced GB EMT model with validation reports
	+ Deliver supporting tools in PSCAD allowing for testing and review
* Produce technical guidance outlining scenarios where EMT simulations are necessary under system critical conditions.

These objectives will be achieved by breaking down the problem into smaller tasks. To achieve the first objective, some methods that will be investigated are:

* Improved network matrix solution methods to accelerate solution speed of network admittance matrix.
* Improve the efficiency of calculating Y matrix formulation
	+ Parallel computing of submodules
	+ Identify if complex control systems of generators and inverters contribute to simulation speed and investigate improvements.
	+ Investigate if new methods can be adopted to partition the network matrix for parallel processing.
* Computationally efficient yet accurate representation of power electronic inverters models – average representation of switching devices
* Improved computer hardware and lower latency when exchanging information between processors.

These tasks are expected to significantly reduce the simulation time of full GB EMT model while maintaining the accuracy and quality of the results.

To produce the EMT scenarios technical guidance the following tasks can be done:

* Prepare the technical guidelines to determine when EMT simulations are necessary
* Perform the simulations and verify the guidelines based on both RMS and EMT simulation results (simulation performed on the GB network)

The project will be delivered in two work packages:

* WP1 - Research & Development to improve the efficiency of EMT simulations run time
* WP2 - Technical Guide to determine when EMT simulations are necessary

In line with the ENA’s ENIP document, the risk rating is scored Low.

TRL Steps = 1 (1 TRL steps)

Cost = 1 (£350k)

Suppliers = 1 (1 supplier)

Data Assumptions = 2

Total = 5 (Low)

* 1. Scope

The scope and objectives of the Project should be clearly defined including the net benefits for consumers (eg financial, environmental, etc). This section should also detail the financial benefits which would directly accrue to the GB Gas Transportation System and/or electricity transmission or distribution.

With Great Britain's (GB) power system moving towards net zero carbon operation, the number of inverter-based resources (IBR) is expected to increase. The amount of synchronous generation in the grid will decline, significantly changing the characteristics of the GB network. These changes, resulting in reduced system inertia and lower short circuit levels, give rise to the potential risk of oscillations and new control interactions between the devices across the network. Conventional RMS analysis can no longer accurately identify system security risks during these conditions. Therefore, EMT analysis is required to conduct research to determine system operational risks with high penetration of IBRs.

EMT simulations take much longer than RMS simulations, even for simple networks. The currently developed full GB EMT model developed through a separate innovation project takes a few hours to run in PSCAD. Furthermore, with the increasing number of IBR sources in the GB system, EMT simulations must be carried out for many scenarios and several contingency cases to analyse system stability. There is an increasing need to develop a capability to carry out multiple EMT analyses, for a more comprehensive network, with reduced simulation time. Additionally, strategies must be developed to correctly identify scenarios requiring EMT analysis more than RMS analysis, as more effort is required for network modelling for EMT analysis.

The project will aim to enhance the GB network's EMT model by improving the models' computational efficiency, which will help the ESO investigate more scenarios with stability risks while transitioning into zero carbon operation. It will also provide technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.

* 1. Objectives

This cannot be changed once registered.

The project has two main objectives:

* Research and development will be performed to improve the efficiency of EMT simulations, with the overall objective of running the National Grid (England & Wales) Electricity network model in PSCAD to achieve practical run time.
* Produce technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.
	1. Consumer Vulnerability Impact Assessment (RIIO-2 projects only)

Details of the expected effects of the Method(s) and Solution(s) upon consumers in vulnerable situations. This must include an assessment of distributional impacts (technical, financial and wellbeing-related). For RIIO-1 projects please add “Not Applicable”

The ESO does not have a direct connection to consumers, and therefore is unable to differentiate the impact on consumers and those in vulnerable situations. Benefits to all consumers are detailed below..

* 1. Success Criteria

Details of how the Funding Licensee will evaluate whether the Project has been successful. This cannot be changed once registered.

Success Criteria:

* Developed methods to accelerate EMT simulation time, will be integrated on the full scale EMT GB network model. This will allow the ESO to “speed up” the process when performing simulations and improve the flexibility of performing transient studies.
* The ESO will have the ability to perform operation studies on the full EMT model of GB, without the need for expensive specialised hardware
* The framework and guidelines will significantly help to illustrate through practical and real examples the limitations of RMS vs EMT tools. That will benefit ESO in understanding which simulation tool to use for which purpose as the GB network transitions to a zero-carbon system.
* Provide actionable insight to improve EMT analysis efficiency and improve understanding of transient interactions and events that could be missed with current tools.
* Dissemination and training for learnings and methods developed in the project.
	1. Project Partners and External Funding

Details of actual or potential Project Partners and external funding support as appropriate.

Manitoba Hydro International (MHI) will be carrying out the work. No external funding required*.*

* 1. Potential for New Learning

Details of what the parties expect to learn and how the learning will be disseminated.

* Applying different innovative methods to improve the efficiency of EMT simulations will enable extensive analysis with a feasible computational process time. This is currently limited to known and prioritised scenarios due to the massive computational time required per scenario.
* This project will also benefit the ESO in building on the learnings already gathered from other innovation projects in EMT modelling.
* This project will allow for a significant understanding of practical and real examples of the limitation of RMS vs EMT tools and which simulation tool to use for which purpose as the GB network transitions to a zero-carbon system (with more complex stability issues becoming of concern in a decarbonised network).
	1. Scale of Project

The Funding Licensee should justify the scale of the Project – including the scale of the investment relative to the potential benefits. In particular, it should explain why there would be less potential for new learning if the Project were of a smaller scale.

The project spans 21 months with one project partner (i.e. MHI). The project consists of desk-based research and workshops with the relevant NGESO teams.

* 1. Geographical Area

Details of where the Project will take place. If the Project is a collaboration, the Funding Licensee area(s) in which the Project will take place should be identified.

We will be based upon the GB ESO area of operations.

* 1. Revenue allowed for in the current RIIO settlement

An indication of the funding provided to the network licensee within the current RIIO settlement that is likely to be surplus to requirements as a result of the Project.

None

* 1. Indicative Total NIA Project Expenditure

An indication of the total Allowable NIA Expenditure that the Funding Licensee expects to reclaim for the whole of the Project (RIIO1).

An indication of the Total NIA Expenditure that the Funding Licensee expects to reclaim for the whole of the Project (RIIO2).

£350,000

1. Project Eligibility Assessment

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

* 1. Requirement 1 - facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

* + 1. How the Project has the potential to facilitate the energy system transition:

With increased penetration of IBR in the energy transition, more EMT analysis will be required for wider regions in the system. This project will support the ESO processes requiring more EMT analysis and help capture and provide insight into transient interactions and events that could be missed with the current tools. This will directly impact future constraint costs and customer connection processes.

* + 1. How the Project has potential to benefit consumer in vulnerable situations:

* 1. Requirement 2 / 2b - has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter’s and/or Electricity Transmission or Electricity Distribution licensee’s network, or wider benefits, such as social or environmental.

* + 1. Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)
		2. Please provide a calculation of the expected benefits the Solution

 This is for Development or Demonstration Projects, not required for Research Projects. It should be (Base Cost – Method Cost, Against Agreed Baseline) and include a description of the recipients of the benefits.

The project will enhance the GB network's EMT model by improving the models' computational efficiency, which will help investigate more scenarios with stability risks while transitioning to zero carbon operation. It will also provide technical guidance outlining scenarios where EMT simulations are necessary under critical system conditions.

The learnings from this project will also be beneficial to Transmission Owners (TOs) concerning the run time of their respective EMT networks. The TOs use the same EMT software package, and the developed tool should be able to integrate with their models seamlessly. Furthermore, the second phase of the innovation project will produce technical guideline outlining the scenarios for which EMT simulations are necessary under system-critical conditions for better-informed decisions.

* + 1. Please provide an estimate of how replicable the Method is across GB

This must be in terms of the number of sites, the sort of site the Method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.

The project will aim to test the methods in the England and Wales networks, with the aim to roll out for the full GB system once the concept is proven.

* + 1. Please provide an outline of the costs of rolling out the Method across GB.

The required software and hardware to run the system estimated cost is £130k

* 1. Requirement 3 / 1 – involve Research, Development or Demonstration
		1. RIIO-1 Projects

A RIIO-1 NIA Project **must have the potential to have a Direct Impact on a Network Licensee’s network** or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

|  |  |
| --- | --- |
| A specific piece of new (i.e. unproven in GB, or where a Method has been trialled outside GB the Network Licensee must justify repeating it as part of a Project) equipment (including control and communications systems and software) |  |
| A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software) |  |
| A specific novel operational practice directly related to the operation of the GB electricity transmission or distribution systems |  |
| A specific novel commercial arrangement |  |

* + 1. RIIO-2 Projects

A RIIO-2 Project must involve the Research, Development or Demonstration of at least one of the following:

|  |  |
| --- | --- |
| A specific piece of new equipment (including monitoring, control and communications systems and software) |  |
| A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven  |  |
| A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)  |  |
| A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology  |  |
| A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution |  |
| A specific novel commercial arrangement |  |

* 1. Requirement 4 / 2a – develop new learning

A Project must develop new learning that can be applied by Gas Transporter and/or Electricity Transmission or Electricity Distribution licensees. For RIIO-1 Network Licensees may wish to address challenges specific to their network.

Please answer one of the following:

* + 1. Please explain how the learning that will be generated could be used by relevant Network Licenses

The learnings from this project can also be beneficial to TOs concerning the run time of their respective EMT networks. The TOs use the same EMT software package, and the developed tool should be able to integrate with their models seamlessly. Furthermore, the second phase of the innovation project will produce a technical guideline outlining the scenarios for which EMT simulations are necessary under system-critical conditions for better-informed decisions.

* + 1. Or, please describe what specific challenge identified in the Network Licensee’s innovation strategy is being addressed by the Project (RIIO-1 only)
		2. Is the default intellectual Property Rights (IPR) position being applied?

This cannot be changed once registered.

|  |  |
| --- | --- |
| Yes | No |

If “no”, the following questions must be answered:

* + - 1. Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties:

* + - 1. Describe how any potential constraints or costs caused, or resulting from, the imposed IPR arrangements:

* + - 1. Justify why the proposed IPR arrangements provide value for money for customers:

* 1. Requirement 5 / 2c – be innovative

A Project must be innovative (ie not a business as usual activity) and have an unproven business case entailing a degree of risk warranting a limited Research, Development or Demonstration Project to demonstrate its effectiveness. This could include Projects which are untested at scale, or in relation to which there are risks, which might prevent the widespread deployment of the equipment, technology or methodology.

* + 1. Why is the project innovative?

RIIO-1 projects must include description of why they have not been tried before.

EMT simulations take considerably more time when compared with RMS simulations, even for simple networks. Running a single EMT simulation on the full GB model using the current tool developed through a previous innovation project takes several hours. This project aims to accelerate the simulation time, to tens of minutes instead of several hours. This can be done by developing new mathematical and modelling techniques that will enhance the calculation run time for the GB model without compromising accuracy.

These enhanced EMT techniques haven’t been tested before, and by utilising them, the project will aim to deliver a GB EMT model suitable for practical operation studies. The second phase of the innovation project will produce a technical guideline outlining the scenarios for which EMT simulations are necessary under critical system conditions for better-informed decisions.

* + 1. Why is the Network Licensee not funding the Project as part of its business as usual activities?

Due to the nature of the project and that it is researching potential future impacts to the grid based largely on assumptions, this does not fall into current business as usual (BAU).

* + 1. Why can the Project can only be undertaken with the support of NIA?

This must include a description of the specific risks (e.g. commercial, technical, operational or regulatory) associated with the Project.

The project is in the complex and new area of EMT analysis for wider networks. The methods to be tested are novel and have yet to be trialled on real networks or other commercial tools. Additionally, there are potential risks associated with the uncertainty of the performance enhancement level that would be achieved by the end of the project and how practical the simulation run time will be for the operational planning. The impact of alternative models on the accuracy of the analysis needs to be tested and evaluated before integration into the whole model.

* 1. Requirement 6 / 2d – not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

* + 1. Please demonstrate below that no unnecessary duplication will occur as a result of the Project.
* **TOTEM**: NIA project will deliver a validated full GB model – the proposed project will build on that model to provide the enhanced EMT algorithms and support the practical adoption of wider network EMT analysis
* **Co-Simulation**: a NIA project led by NGET to deliver a platform to run both RMS and EMT simulations simultaneously. As the proposed project will increase the efficiency of the EMT simulation it will in turn improve the co-simulation outcomes. The proposed technical guidance work will identify the processes which can be delivered with accepted level of accuracy in RMS, EMT or co-simulated environment.
* **DETECTS:** a NIA project which provided GB South Coast stability analysis based on detailed EMT analysis – the proposed project can be used as a validation for the improved EMT algorithms that will be delivered in this project.
	+ 1. If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

**Relevant Foreground IPR**
*Please provide a list of the relevant foreground IPR that will be generated in the course of the project e.g. reports, models, tools etc.*

1. Enhanced full GB EMT model
2. Supporting tool in PSCAD for testing and review the model
3. Technical guidance outlining scenarios where EMT simulations are necessary under system critical conditions

**Data Access Details** *(standard ESO response - please do not edit)*

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

1. A request for information via the Smarter Networks Portal at <https://smarter.energynetworks.org>, to contact select a project and click ‘Contact Lead Network’. National Grid ESO already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.
2. Via our Innovation website at <https://www.nationalgrideso.com/future-energy/innovation>
3. Via our managed mailbox innovation@nationalgrideso.com

Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available “Data sharing policy relating to NIC/NIA projects” at <https://www.nationalgrideso.com/document/168191/download>.

1. PEA approval

The senior person (RIIO-1) or senior network manager (RIIO-2) responsible for implementing RIIO-2 NIA Projects must approve the PEA. It must then be published on the Project Registration page of the Smarter Networks Portal.

|  |  |
| --- | --- |
| **Please confirm this project has been approved by a senior member of staff** |  |